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PRELIMINARY

EXAMINATION OF
RADIOGRAPHIC FILMS AND
CONSIDERATIONS OF WELD INTEGRITY OF
PIPE BUTT WELDS IN
$3\frac{1}{2}$" OD BY 0.435" WALL
FEEDWATER PIPING
UNIT No. 1
OCONEE NUCLEAR POWER STATION
DUKE POWER COMPANY

Helmut Thielsch, PE

February 2, 1980

Report No. 1962

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INTRODUCTION

In May 1979, the Indiana and Michigan Power Company discovered cracking in two feedwater lines in Unit No. 2 of the D. C. Cook Power Station. The cracks resulted in leakage through the two pipe sections involved. Subsequent examinations confirmed that the cracks had occurred through the base metal adjacent to the weld joints.

The pipe size was 16" diameter. The cracking occurred in elbows adjacent to the two steam generator nozzle welds. The circumferential cracks resulting in the steam leaks were located on the elbow side of the girth welds.

Similar cracking has occurred in the feedwater piping at other nuclear power stations. In each instance, the cracks developed in the base metal adjacent to the girth welds.

The cracking conditions have been associated primarily with corrosion fatigue, where the fatigue represents the primary cause.

Many similar failures have occurred in piping in fossil fuel power plants, chemical plants, paper mills, and related installations. The failure patterns generally are very similar. The gradually progressive cracking is primarily caused by fatigue and corrosion. These types of failures normally result in leaks. The pipes involved generally are, and have been readily repair welded.

To determine the extent of similar conditions of cracking in various other nuclear plants, the Nuclear Regulatory Commission issued Bulletin No. IE 79-13 (Appendix A). This Bulletin required that Licensees operating steam generators fabricated by Westinghouse or Combustion Engineering perform radiographic examinations of feedwater nozzle-to-pipe welds. The evaluation was to be performed in accordance with Section III of the ASME Boiler and Pressure Vessel Code, Subsection NC, Article NC-500 (Appendix B).

The radiography was to be performed to the 2T penetrameter sensitivity level.

Although the concern should involve primarily evidence of cracking in the pipe base metal, the Licensees were also asked to identify weld defects on the radiographic films.

Evidence of cracking or weld discontinuities were to be reported to the Nuclear Regulatory Commission.

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ORIGINAL WELD FABRICATION

The piping system originally was subject to the requirements of ANSI B31.1. This Standard did not require radiographic examination of the butt welds in the auxiliary feedwater piping, which involves a size of 3½" OD by 0.435" wall. (Other ASME Standards similarly would not require radiographic examination of these butt welds at the applicable design conditions).

An isometric sketch of the auxiliary feedwater piping is shown in Fig. 1. A layout drawing is provided in Fig. 2.

The auxiliary feedwater piping is normally subject to a temperature of 600°F and a pressure of 1100 psig.

The nozzle connections involve welding neck flanges with butt welds between the flanges and the headers, and between the flanges and the pipe leaks. On the pipe side, an elbow is welded to the welding neck flange.

The weld end preparation was a standard 37½° bevel with a 1/8" thick land at the weld root. The weld was fit up without a backing ring and with a weld root spacing of approximately 1/8".

Welding was done by the inert-gas tungsten-arc root pass process. Each butt weld was then completed by shielded metal-arc welding utilizing AWS E7018 electrodes.

The welding procedures and welders were qualified to Section IX of the ASME Boiler and Pressure Vessel Code.

RADIOGRAPHIC EXAMINATION

In accordance with Bulletin IE 79-13, nozzle welds in the feedwater piping of Unit No. 1 at the Oconee Nuclear Power Station were inspected by radiographic examination.

The radiographic examination was performed by the Babcock and Wilcox Company. The radiographic examination was done with Iridium 192 isotopes and Kodak Type DR film.

The radiographic film technique is considered acceptable, as the penetrameters were discernible on the radiographic films. (These conclusions are based upon the examination of the original radiographic films. It is recognized that prints of radiographic films will define somewhat less clearly penetrameters and weld contour variations than the original radiographic film negatives).

Copies of the original inspection reports are provided in Appendix C.

The radiographic films were subsequently examined in detail by personnel representing Duke Power Company, and by this writer.

In addition to the welds, the radiographic films covered at least 1½" of the base metal adjacent to the weld joint. This is the area where normally, cracking associated with fatigue enhanced by corrosion (or corrosion fatigue) has occurred.

WELD INTERPRETATION

There was no evidence of any cracking in the flange or elbow base metals adjacent to the butt welds involved.

There was also no evidence of cracking in any of the weld deposits.

The first interpretation reports are provided in Appendix D.

As would be expected in welds not subject to radiographic examination requirements, intermittent weld defects were apparent in a number of these welds. Typical examples are illustrated in Figs. 3 to 9.

The occasional weld defects involved primarily intermittent porosity and slag and tungsten inclusions. At a few locations, slight concavity was also apparent.

In some instances, the indications which appeared as porosity actually represented entrapped weld splatter. This is evidenced by the ring-like, rather than spherical hole-like appearance of the porosity. This may be due to difficulties in accessibility around the weld circumference. These splatter inclusion type defects, however, are not critical.

The weld roots generally exhibited good ID root appearance. In some instances, where the underside of the weld and the inside of the pipe were accessible for the open flange end, the welder also appears to have done some grinding of the weld underside.

The root weld bead, particularly where it penetrates below the inside pipe surface, may exhibit root bead edges. This may give the appearance of a slag line on the radiographic film. This condition tends to occur at tack welds, or in weld repairs. It is neither harmful nor rejectable.

DISCUSSION

The weld quality is typical of acceptable pipe welds made under Section I of the ASME Boiler and Pressure Vessel Code, or the American National Standards Institute B31.1, as applicable to feedwater piping involving sizes not subject to radiographic examination.

Where subsequent radiographic examinations are performed for information, these welds generally have been judged as acceptable. Failures have not resulted from the types of internal weld defects apparent on the radiographic films examined.

Many of the defects are well within the acceptable limits of the ASME Boiler and Pressure Vessel Code. In a few instances, the defects would be considered borderline under the interpretation standards, even though they would not cause cracking and weld failures. Moreover, where these defects are considered borderline, different examiners may apply different interpretations. Thus, one Level II Examiner may consider a particular weld acceptable, whereas a second Examiner may consider the same level of weld defects as not acceptable.

Based on normal requirements applicable to feedwater piping, there were no rejectable weld defect conditions which would affect weld integrity, or the ability of the pipe welds to perform satisfactorily.

None of the minor weld defects apparent involving primarily slag or tungsten inclusions or porosity would either cause or contribute to the type of nozzle, or pipe cracking conditions described in Nuclear Regulatory Commission Bulletin IE 79-13.

The weld appearance is good and adequate for weld joints welded to American National Standards Institute ANSI B31.1, or B31.7, and to Section I of the ASME Boiler and Pressure Vessel Code.

In one weld joint identified as weld   , which had been examined separately, and was not reviewed by this examiner, the initial radiographic examination had identified a "root" condition as lack of fusion (LF), or lack of penetration (LP). The weld joint was subsequently removed and examined from the inside. This examination confirmed that neither lack of penetration nor lack of fusion was apparent. The surface indication responsible for this interpretation actually involved a root mismatch, which tends to occur, on occasion, on weld joints between elbow and pipe sections. This condition would not have represented a defect condition requiring repair, even under current Codes.

Inconsequential internal weld defects which do not reduce significantly the pipe wall thickness at the locations of the weld joints, and which do not tend to propagate into cracks, generally should not be repaired by welding. The reason is that the weld repairs tend to produce higher levels of localized residual stresses. These are far more significant than the inconsequential internal weld defects.

There have been many instances where excessive weld repairs have subsequently led to cracking (usually starting in the adjacent base metal), whereas the original welds did not evidence cracking originating from weld defects.

In most piping systems, a high residual stress, which is not detectable on radiographic films or in ultrasonic examinations, may be far more detrimental to the integrity of a weldment than a weld defect such as a slag line, porosity, or even lack of fusion, which does not extend significantly through the pipe wall thickness.

The weld defect conditions apparent in the butt welds examined in the feedwater piping covered by this report are considered entirely inconsequential, and not of a type which result in weld failures. This applies even to piping systems subject to significant fatigue. If such significant fatigue should occur with or without corrosion (i.e., fatigue or corrosion fatigue), the resulting cracking will tend to initiate and propagate from the inside surface through the wall thickness in the base metal along either side of the weld joint. This has been confirmed by large numbers of failure analyses performed on piping systems subject to fatigue, and involving piping in fossil fuel power plants, nuclear power plants, petrochemical plants, paper mills and other installations.

CONCLUSIONS

The butt welds in the feedwater piping adjacent to the flanges on the "A" and "B" Risers represent acceptable quality levels in accordance with the requirements of ANSI B31.1 and B31.7.

The weld defects apparent represent intermittent defect conditions generally considered acceptable in radiographic film interpretation standards applicable to weld joints in critical high-temperature high-pressure piping.

These defects have not reduced the integrity of the feedwater pipe welds involved. They will not result in failures in piping systems subject to fatigue and/or corrosion fatigue.

Repair by welding of specific isolated weld defects would not improve further the acceptable level of integrity of the piping.

The radiographic examinations also confirm the absence of cracking in the nozzle, elbow, or welding neck flange base materials, where cracking in some feedwater system piping has occurred in other nuclear power plants.

The feedwater piping at the "A" and "B" riser connections is suitable for continued service.

APPENDIX D(1)

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FEEDWATER PIPING

"A" - Riser

Weld Identification	Film Section	Interpretation	Acceptance	Comments
"A" 1-ELB	1-2	P_B, T_A	OK	Porosity and entrapped weld splatter
	2-3	P_B	OK	
	3-4	S_A, P_A	OK	
	4-1	P_A, T_A	OK	Porosity and entrapped weld splatter
"A" 1-FLG	1-2	P_A	OK	
	2-3	S_A, T_A	OK	
	3-4	T_A, S_A, T_A	OK	
	4-1	T_A, S_A, P_A	OK	
"A" 2-ELB	1-2	P_A, S_A	OK	
	2-3	P_B, S_A	OK	Fig. 3 entrapped splatter
	3-4	P_B, T_A	OK	
	4-1	P_B, S_A	OK	Entrapped splatter
"A" 2-FLG	1-2	P_A, CC_A	OK	
	2-3	P_A, T_A	OK	
	3-4	S_A, P_A	OK	
	4-1	P_A, S_A	OK	
"A" 3-ELB	1-2	P_B, S_A	OK	
	2-3		OK	Entrapped splatter Fig. 4
	3-4	BT_A	OK	
	4-1	P_A	OK	
"A" 3-FLG	1-2	P_A	OK	
	2-3	P_A, S_A	OK	
	3-4			Film section missing
	4-1	P_A	OK	
"A" 5-ELB	1-2	P_A, S_A, T_A	OK	
	2-3	P_A, T_A	OK	
	3-4	T_A, P_A, S_A	OK	
	4-1	P_B, T_A	OK	Entrapped weld splatter
"A" 5-FLG	1-2	P_A	OK	
	2-3	P_A	OK	
	3-4	P_A	OK	
	4-1	P_B, T_A	OK	Entrapped weld splatter

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Weld Identification	Film Section	Interpretation	Acceptance	Comments
"A" 6-ELB	1-2	P_A, T_A, S_A	OK	Entrapped weld splatter
	2-3	P_A, T_A	OK	Convexity
	3-4	P_A, CC_A	OK	
	4-1	CC_A, T_A, P_A	OK	
"A" 6-FLG	1-2	P_A, S_A	OK	
	2-3	CC_A	OK	Fig. 5 root bead edge surface condition
	3-4	P_A	OK	Fig. 6 root bead edge (probably partially ground)
	4-1	P_A, T_A, CC_A	OK	
"A" 7-ELB	1-2	T_A, BT_A	OK	
	2-3	P_A	OK	
	3-4	P_A, S_A	OK	
	4-1	P_B, BT_A	OK	Fig. 7 cluster of porosity. NOTE: Weld appears to have been taper
"A" 7-FLG	1-2	P_A, S_A	OK	
	2-3	P_A, S_A	OK	
	3-4	P_A, S_A	OK	
	4-1	P_A	OK	

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FEEDWATER PIPING

"B" - Riser

Weld Identification	Film Section	Interpretation	Acceptance	Comments
"B" 1-ELB	1-2	P_A	OK	
	2-3	P_B, CC_A	OK	Fig. 8 entrappe weld splatter
	3-4	CC_A	OK	
	4-1	P_A, T_A, CC_A	OK	
"B" 1-FIG	1-2	P_A, CC_A	OK	
	2-3	P_A, CC_A	OK	
	3-4	P_A, S_A	OK	
	4-1	P_B, T_A, S_A	OK	Cluster porosit
"B" 2-ELB	1-2	P_A, S_A	OK	
	2-3	P_B	OK	Entrapped weld splatter
	3-4	BT_A, T_A, P_A	OK	
	4-1	P_A	OK	Root bead edges.
"B" 2-FLG	1-2	P_A	OK	
	2-3	P_A	OK	
	3-4	P_A	OK	Root bead edge
	4-1	P_A	OK	
"B" 3-ELB	1-2	P_A	OK	
	2-3	P_A, T_A, CC_A	OK	Fig. 9
	3-4	P_A, T_A	OK	
	4-1		OK	
"B" 3-FLG	1-2	P_A, CC_A	OK	
	2-3	P_A, CC_A	OK	
	3-4	P_A, CC_A	OK	
	4-1	P_A, T_A	OK	
"B" 5-ELB	1-2	P_A, T_A	OK	
	2-3	P_A, T_A, S_A, BT_A	OK	
	3-4	P_A, T_A, CC_A	OK	
	4-1	P_A, BT_A	OK	
"B" 5-FLG	1-2	P_A, T_A, CC_A, BT_A	OK	
	2-3	P_A, T_A	OK	
	3-4	P_A, T_A	OK	
	4-1	P_A	OK	
"B" 6-ELB	1-2	P_A, T_A, CC_A	OK	
	2-3	T_A, P_A	OK	
	3-4	P_A, CC_A	OK	Root bead edge
	4-1	P_A, T_A	OK	

Weld Identification	Film Section	Interpretation	Acceptance	Comments
"B" 6-FLG	1-2	CC_A, S_A, T_A	OK	
	2-3		OK	
	3-4	S_A		
	4-1	S_A, P_A	OK	
"B" 7-ELB	1-2	P_A, T_A	OK	
	2-3	P_A	OK	Root bead edge
	3-4		OK	
	4-1	P_A, T_A	OK	Root bead edge
"B" 7-FLG	1-2	P_A	OK	
	2-3	P_A, CC_A	OK	
	3-4	P_A, S_A	OK	
	4-1	P_A, S_A	OK	

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Unrealistic quality assurance: a crack in nuclear piping integrity

Well-intentioned quality assurance programs may actually cause failures in some cases

By **HELMUT THIELSCH,**
Vice President, Research, Development, and Engineering, ITT Grinnell Corp., Providence, R.I.

In recent years, much has been said about unrealistic and excessively tight quality assurance requirements applied to nuclear power plants that have increased plant costs by many millions of dollars without contributing to greater plant system integrity. Increasingly tight requirements are being applied to the materials utilized in piping systems, valves, vessels, containment and other components in nuclear power plants.

Many unrealistic rejections are related to a lack of understanding of engineering materials and their performance. Thus, understanding the characteristics of engineering materials and their performance in different shapes in specific service environments is essential to more realistic quality assurance programs.

Responsible materials engineering includes recognition that although plants must be safe and reliable and must utilize materials and products that meet code requirements, they must be engineered and constructed at the lowest possible cost.

The overall purpose of quality assurance is to avoid service failures. Failures, obviously, may have been caused by defects in materials, products, or design, but failures have also been caused by excessive rework to provide "cosmetic" improved appearance.

1 Rupture of 12 in. outside diameter stainless steel elbow due to cracking along weld overlaid heat affected zone adjacent to seam weld.

Unrealistic or misunderstood quality assurance may result in excessive repairs of engineering materials. Such repairs, although improving the "interpretability" of inspection results, may in fact reduce the integrity of the repaired components. A severe catastrophic failure, for example, was caused by excessive cosmetic grinding of a stainless steel fitting. The ruptured seam welded elbow involved is shown in Fig. 1. Upon completion of the seam weld in the 14 in. stainless steel elbow, the manufacturer ground the weld seam. Because of overgrinding, which reduced the base metal wall thickness excessively, he subsequently applied a weld overlay extending by 1 in. over the base metal beyond the original butt weld. The particular stainless steel involved is subject to severe grain growth in the heat affected zone, which exhibits lower high strength properties at elevated temperature than either base metal or the weld metal. The cracking that

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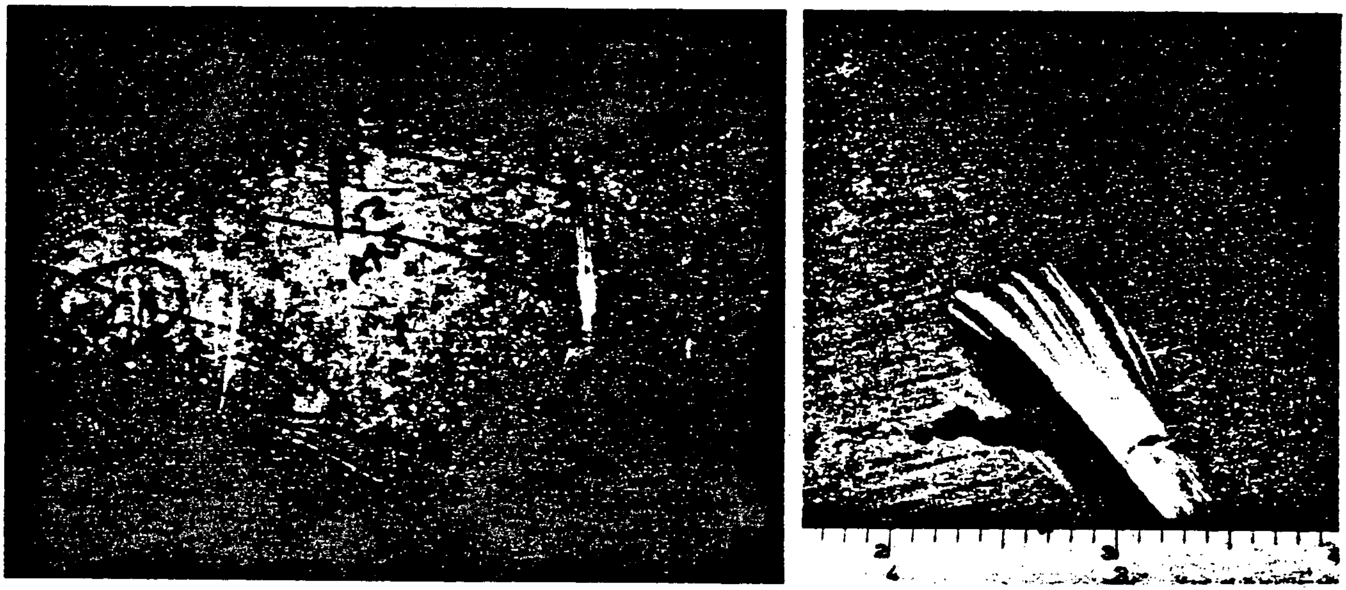
This article is based on a paper presented at the International Energy Engineering Congress at Chicago, Ill. on November 5, 1975 under the sponsorship of James O. Rice Associates, Inc., 400 Madison Ave., New York, NY 10017.

5 Illustration of typical surface lap on 14 in. seamless carbon steel pipe.

Repairs, although improving the interpretability of inspection results, may in fact reduce the integrity of the repaired components



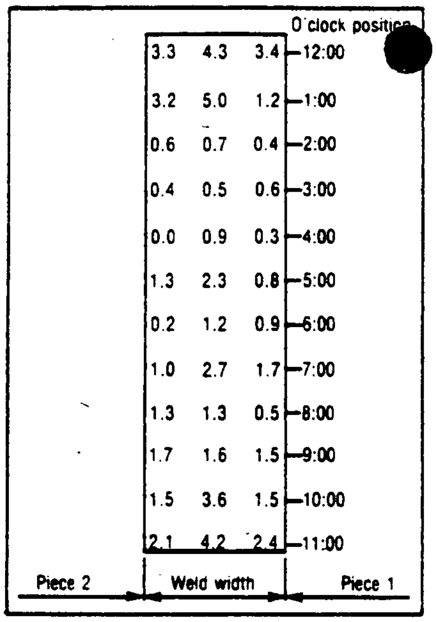
6 Photo A (left) shows surface laps on seamless 20 in. outside diameter Schedule 80 (1.031 in. wall) carbon steel pipe from 0.023 to 0.056 in. deep representing 2.2 to 4.9 percent of the pipe wall thickness. Photo B (right) shows surface lap on seamless 26 in. outside diameter by 0.975 wall carbon steel pipe 0.075 in. deep representing 8.6 percent of pipe wall thickness.

rewelding was necessary at the nuclear power plant construction site. Major schedule delays and high costs resulted. Grinding or filing across a few selected surface laps was an entirely acceptable procedure that confirmed that the laps in the particular piping were completely inconsequential (Fig. 6). The specific manufacturer's pipe products were thus proven entirely acceptable.

Many similar resolutions applied to various other piping products can be cited. Additional examples in stainless steel pipe, forged fittings, and forged valves, where surface defects have been confirmed as acceptable by material and mechanical test analyses, are shown in Figs. 7 to 9.

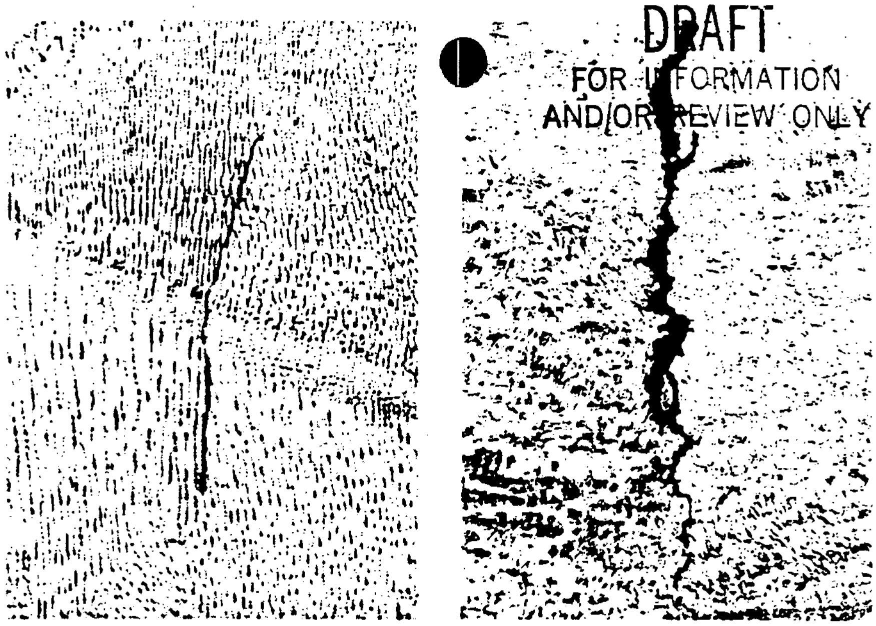
Whereas piping material specifications broadly define welding processes, variations in the processes and/or procedures can result in defects not readily detectable. On the average, pipe and fitting seam welds welded without filler metal tend to be superior to seam welds made with filler metal. The reason is that for welding seams in piping and fittings without filler metal, the inert gas tungsten arc welding processes must be employed. Thus, less rigid inspection requirements should apply to fittings and pipe seams welded without filler metal.

With respect to shop fabrication or field erection, welding procedures generally are pre-established and written with rather tight control over various welding parameters. When specific problems then arise during production welding, it often becomes extremely difficult or at times impractical or even impossible to make changes in specific welding procedures or parameter details. For example, on one nuclear project, the welding of containment pipe sections involved both welds in 24 in. diameter pipe located 12 in. from the containment wall. The pipe had been prepared with J-bevel preparation involving a 10 deg taper on the J-bevel. The welders had problems with electrode manipulation because of interference from the containment wall (Fig. 10). The weld deposits were unevenly filled; *i.e.*, each weld layer was an angle rather than parallel to the centerline (Fig. 11). The weld-



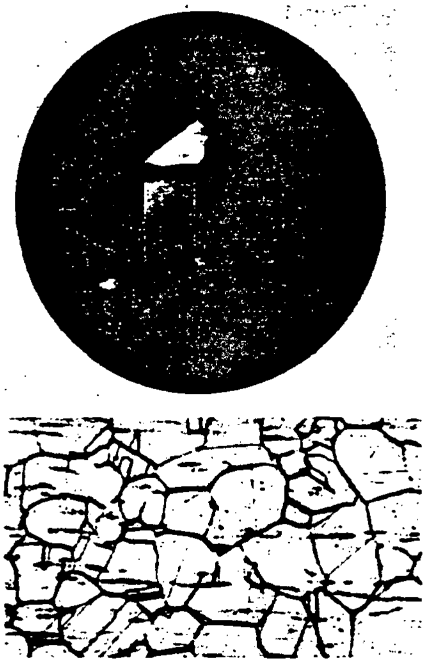
			O'clock position
3.3	4.3	3.4	12:00
3.2	5.0	1.2	1:00
0.6	0.7	0.4	2:00
0.4	0.5	0.6	3:00
0.0	0.9	0.3	4:00
1.3	2.3	0.8	5:00
0.2	1.2	0.9	6:00
1.0	2.7	1.7	7:00
1.3	1.3	0.5	8:00
1.7	1.6	1.5	9:00
1.5	3.6	1.5	10:00
2.1	4.2	2.4	11:00

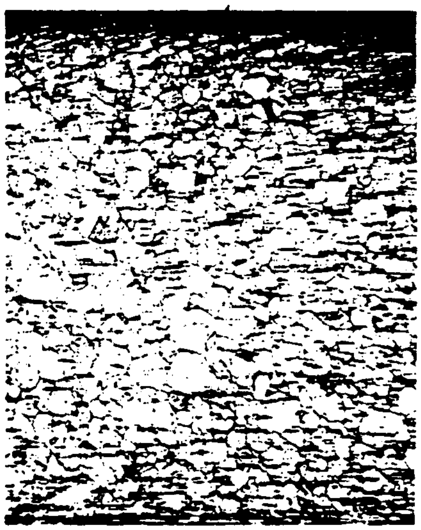
12 Delta ferrite measurements around circumference of 2 in. wide butt weld in 14 in. outside diameter by 1.25 in. wall Type 316 stainless steel pipe.



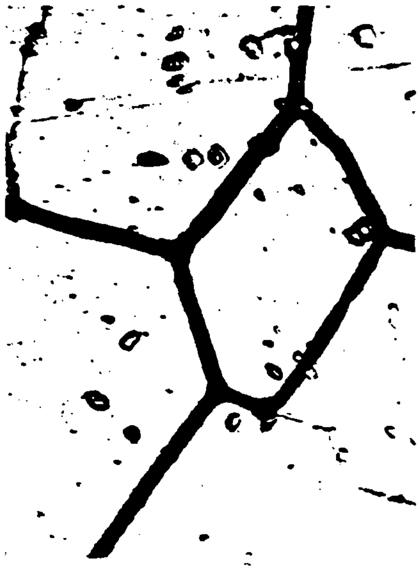
13 Examples of microfissures in Type 316 stainless steel weld joints containing 1 percent delta ferrite (Photo A, left) and 10 percent delta ferrite (Photo B, right). Both photos are reproduced at 100 X magnification.

14 Views of socket weld in Type 304 stainless steel coupling with severe sensitization along inside surface of pipe as confirmed by ASTM oxalic acid sensitization etch test evidencing a ditched grain structure. Photo at left is a 1 X magnification; the bottom left, 100 X; and bottom right 500 X.





15 Example of sensitization along the inside surface of pipe sensitized by normal pipe forming. Photo at top is at 25 X magnification; bottom photo is at 500 X magnification.

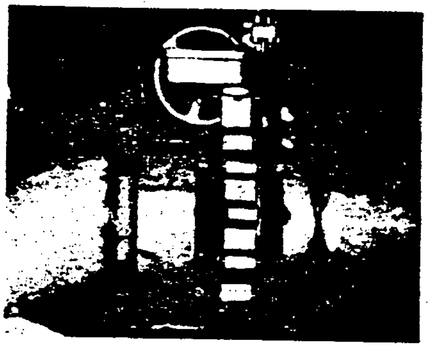


struction, or erection procedures.

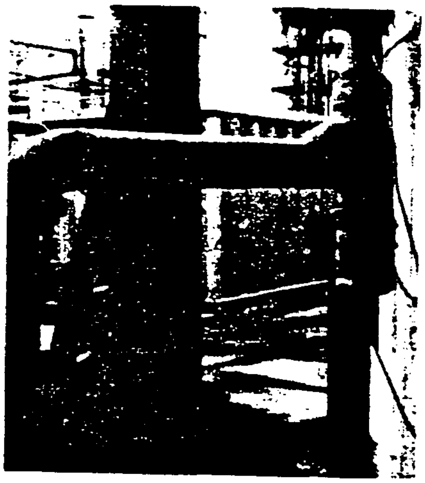
Rather tight requirements have been applied to weld deposits in stainless steel piping with respect to delta ferrite levels. Many welds have been rejected and have required rewelding because they contained delta ferrite levels of less than 5 percent or greater than 15 percent. Extensive delta ferrite measurements from various nuclear power plant projects showed levels as low as ½ percent or even as high as 25 percent or higher. An example of low ferrite levels in an entirely acceptable weld in Class I piping is shown in Fig. 12. Experience with stainless steel welds in the chemical industry also confirms that fully austenitic weld deposits have not failed in service, even though microfissures were present. In fact, microfissures can be present in welds with delta ferrite contents of 10 to 15 percent (Fig. 13). The weld deposits nevertheless exhibit high levels of integrity.

Delta ferrite measurements made on stainless steel castings installed in many nuclear power plants have shown levels ranging from 0 to as high as 50 percent. These castings provide satisfactory service in nuclear power plant installations, even

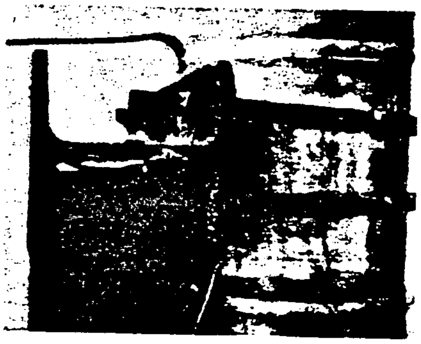
19 Another illustration of shimming of stainless steel pipe with stainless steel strip metal in carbon steel support assembly.



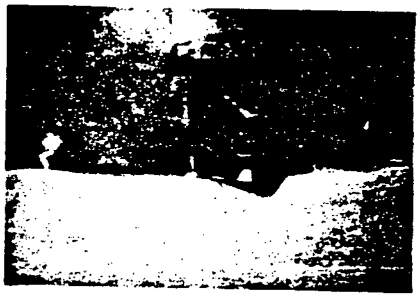
20 Carbon steel pipe clamp and carbon steel slip-on flanges on stainless steel pipe in fossil fuel power plant.



21 Examples of carbon steel U-bolts on stainless steel pipe involving outdoor installation in chemical plant.



22 Example of rust surface layer on stainless steel pipe adjacent to weld deposit made by shielded metal arc welding.



23 Thin surface layer on stainless steel pipe adjacent to lug weld made by inert gas tungsten arc welding.

Excessive surface cleaning to remove every spot of rust does not result in greater piping integrity

clusions and porosity and to minimize weld rejections and repairs.

- Resolutions and acceptance of various "contaminations" apparent on stainless steel weld, pipe, and vessel surfaces, and including discoloration, rust, chemicals, etc.
- Reducing gas purging requirements without affecting weld quality of pipe butt welds.
- Resolutions of weld rejections involving "excessive" weld reinforcement on the underside of weld joints as estimated by radiographic or ultrasonic examinations.
- Review resolution and acceptance of Class III or Class II piping installed in Class II or Class I piping systems.
- Acceptance of carbon steel to chromium-molybdenum dissimilar weld joints that were welded without preheat treatment.
- Acceptance of valves with wall thickness areas below minimum design wall thickness requirements, as determined by ultrasonic examinations, and/or actual measurements.
- Examination and resolution of piping materials, pumps, valves, and/or pipe supports subject to fire exposure.
- Evaluation, resolution, and acceptance of linear indications in weld deposits, weld repairs, or weld cladding overlays detected by liquid penetrant examination after surface grinding.

Many more examples could be cited!

By realistically evaluating the characteristics and performance of the materials used in nuclear power plants and applying these results in the specification and interpretation of quality assurance requirements, very significant cost reductions can be realized on many current nuclear power plant projects without in any manner adversely affecting the integrity of the piping, vessels, components, and systems.

Materials engineering know-how and extensive performance experiences of the respective components in various environments are essential ingredients in the resolution process. Much can be learned in this respect from product performance and failure analysis experiences in the chemical and petrochemical plants, fossil fuel power plants, paper mills, and mining and metal processing plants.

Total support of this by the utility's management is essential. If effectively implemented, the result would be reliable nuclear power plants at lower costs.

Similar reduction in costs and improvements in quality and integrity have been identified with respect to repair and maintenance, and in-service inspection. -

The

American Society for Nondestructive Testing

Be it known that

Helmut Thielsch

has met heretofore established and published Requirements for Certification by ASNT as

NDT Level III

In the Nondestructive Testing Methods as specified in the Endorsements

President - ASNT

Chairman - Personnel Training and Certification Committee

RB 733
Certificate Number

Endorsements - The Holder of this Certificate has been Certified by ASNT as NDT Level III in the General Requirements for the NDT Methods specified below:

Certificate No. RB 733
Radiography
TESTING METHOD
12-77 DATE ISSUED
2-81 DATE EXPIRES
TECHNICAL DIRECTOR ASNT

Certificate No. RB 733
Magnetic Particle
TESTING METHOD
12-77 DATE ISSUED
2-81 DATE EXPIRES
TECHNICAL DIRECTOR ASNT

Certificate No. RB 733
Ultrasonic
TESTING METHOD
12-77 DATE ISSUED
2-81 DATE EXPIRES
TECHNICAL DIRECTOR ASNT

Certificate No. RB 733
Penetrant
TESTING METHOD
12-77 DATE ISSUED
2-81 DATE EXPIRES
TECHNICAL DIRECTOR ASNT

Certificate No. RB 733
Leak Testing
TESTING METHOD
12-77 DATE ISSUED
2-81 DATE EXPIRES
TECHNICAL DIRECTOR ASNT

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